

of thermometers, provided with a handle as shown in Fig. 1, which permits the thermometers to be whirled rapidly, the bulbs being thereby strongly affected by the temperature of and moisture in the air. The bulb of the lower of the two thermometers is covered with thin muslin, which is wet at the time an observation is made.

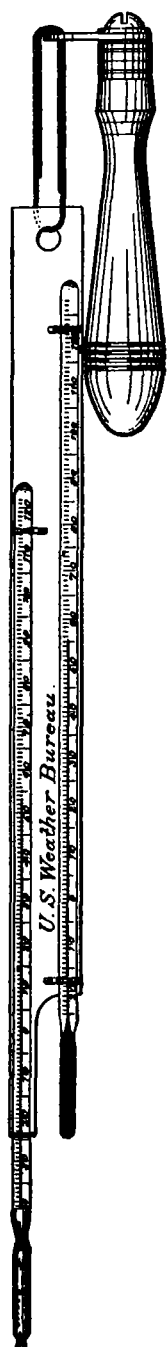


FIG. 1.—Sling psychrometer.

The wet bulb.—It is important that the muslin covering for the wet bulb be kept in good condition. The evaporation of the water from the muslin always leaves in its meshes a small quantity of solid material, which sooner or later somewhat stiffens the muslin so that it does not readily take up water. This will be the case if the muslin does not readily become wet after being dipped in water. On this account it is desirable to use as pure water as possible, and also to renew the muslin from time to time. New muslin should always be washed to remove sizing, etc., before being used. A small rectangular piece wide enough to go about one and one-third times around the bulb, and long enough to cover the bulb and that part of the stem below the metal back, is cut out, *thoroughly wet* in clean water, and neatly fitted around the thermometer. It is tied first around the bulb at the top, using a moderately strong thread. A loop of thread to form a knot is next placed around the bottom of the bulb, just where it begins to round off. As this knot is drawn tighter and tighter the thread slips off the rounded end of the bulb and neatly stretches the muslin covering with it, at the same time securing the latter at the bottom.

To make an observation.—The so-called wet bulb is thoroughly saturated with water by dipping it into a small cup or wide-mouthed bottle. The thermometers are then whirled rapidly for fifteen or twenty seconds; stopped and quickly read, the *wet bulb* first. This reading is kept in mind, the psychrometer immediately whirled again and a second reading taken. This is repeated three or four times, or more, if necessary, until at least two successive readings of the wet bulb are found to agree very closely, thereby showing that it has reached its lowest temperature. A minute or more is generally required to secure the correct temperature.

When the air temperature is near the freezing point it very often happens that the temperature of the wet bulb will fall several degrees below freezing point, but the water will still remain in the liquid state. No error results from this, provided the minimum temperature is reached. If, however, as frequently happens, the water suddenly freezes, a large amount of heat is liberated, and the temperature of the wet bulb immediately becomes 32°. In such

cases it is necessary to continue the whirling until the ice-covered bulb has reached a minimum temperature.

Whirling and stopping the psychrometer.—It is impossible to effectually describe these movements. The arm is held with the forearm about horizontal, and the hand well in front. A peculiar swing starts the thermometers whirling, and afterward the motion is kept up by only a slight but very regular action of the wrist, in harmony with the whirling thermometers. The rate should be a natural one, so as to be easily and regularly maintained. If too fast, or irregular,

the thermometers may be jerked about in a violent and dangerous manner.

The stopping of the psychrometer, even at the very highest rates, can be perfectly accomplished in a single revolution, when one has learned the knack. This is only acquired by practice, and consists of a quick swing of the forearm by which the hand also describes a circular path, and, as it were, follows after the thermometers in a peculiar manner that wholly overcomes their circular motion without the slightest shock or jerk. The thermometers may, without very great danger, be allowed simply to stop themselves; the final motion in such a case will generally be quite jerky, but, unless the instrument is allowed to fall on the arm, or strikes some object, no injury should result.

Exposure.—While the psychrometer will give quite accurate indications, even in the bright sunshine, yet observations so made are not without some error, and, where greater accuracy is desired, the psychrometer should be whirled in the shade of a building or tree, or, as may sometimes be necessary, under an umbrella. In all cases there should be perfectly free circulation of the air, and the observer should face the wind, whirling the psychrometer in front of his body. It is a good plan, while whirling, to step back and forth a few steps to further prevent the presence of the observer's body from giving rise to erroneous observations.

The relation between the readings of the psychrometer and the pressure of the vapor of water mixed with the air is not perfectly understood, although several empirical formulæ have been developed which express this relation more or less exactly. The tables employed by the Weather Bureau were computed by Professor Ferrel's formula, the constants of which were determined from a large number of comparative observations of the psychrometer and Regnault's dew-point apparatus (see W. B. No. 127). The formula is:

$$p = F - 0.000360 (t - t') (1 + 0.00065 t') P$$

p is the desired pressure of the aqueous vapor.

F is the maximum pressure corresponding to saturation at the temperature of the wet bulb.

t equals the air temperature; t' the wet bulb temperature, and P the barometric pressure.

THE UMBRELLA CLOUD.

By MR. WILLARD D. JOHNSON.

In the *Meteorologische Zeitschrift* for January, 1896, M. Streit has given an illustration of a remarkable cloud formation, designated as "umbrella cloud," observed in northern Italy. Recently the Editor became aware of an equally interesting formation carefully observed in Kansas and also called an "umbrella cloud" by its discoverer, Mr. Willard D. Johnson, of the U. S. Geological Survey. Mr. Johnson made two sketches of the cloud in his field notebooks and subsequently Mr. DeLancey W. Gill made a more elaborate drawing for him. Reprints of these, by photogravure, are given in the accompanying charts, XI and XII. The Editor deems it important to reproduce the sketches from the field notes, in order that the student may distinguish between those features of the completed drawing that have been filled in from memory and those that have the sketches as a basis. Mr. Johnson writes as follows under date of May 13, 1898:

The date was July 25, 1896. My point of view was 1 mile northwest of Garden City, Kans. The time was about ten minutes of 4 p. m. [? central time]. I was looking nearly due west. The cloud was also observed by Mr. H. W. Menke, of Garden City, a graduate of the University of Kansas. He was about 4 miles to the northwest of my position. He made a photograph with a small pocket camera. As he was not looking toward an illuminated portion of the sky, as I was, the outlines were not so clearly defined. At any rate, his little photograph gives no details; the general outline, however, of the lower truncated cone is plainly distinguishable and agrees very well with the extraordinary form in my sketch.

Mr. Menke, writing from memory, on April 6, 1898, criticises the form of the upper portion of my sketch, a copy of which I had sent to him. He says the overlapping plates appeared to him in rolls increasing in size outward. I think my sketch is to be trusted in this respect, however. The edges of the plates are perhaps too definitely outlined, perhaps also too thin. By combining observations of my own and Mr. Menke I estimate the distance of the cloud in my sketch to be from 8 to 12 miles.

The day had been clear and the windlight. Stormy conditions came on rather abruptly. I regret that I did not notice the beginning of the cloud formation. My attention was called to it by one of my party. I infer that it had but recently formed about where we saw it, otherwise, it seems to me some one of us would have noticed it earlier. I could detect no evidence of a whirling motion, that is, any other than, as you can see, the form itself suggests. I made a memorandum at the time to the effect that appearances seem to indicate that the cloud formed suddenly and had matured just before my attention was called to it. My reason for thinking so was this: The outer edge at the bottom was here and there very sharply outlined, as though it had been entirely symmetrical, and was now breaking up. As I watched it, this departure from symmetry seemed to increase. I recall now, though I did not note it at the time, that the central whirls at the neck, or the smallest portion, were perfectly symmetrical, apparently, and *here* there may have been rapid motion. But if there had been rapid motion at the bottom, at the outer edge of the larger circle, I could have measured it by watching the little defects in the circle.

The whole mass—that is, the broad black cloud, from which the umbrella figure is pendant—was not itself very large, that is, it did not cover more than half of the sky, as I saw it. It was also irregular in outline. The umbrella cloud was pendant from about its center. The sky beyond was brilliant with here and there cumulus clouds. The black and formless character of the cloud mass in general is well indicated in the sketch. I think I have not in the least exaggerated the striking character of the umbrella feature. It was exceedingly remarkable in appearance and excited much local comment. I found but one person who had ever seen such a thing before and he gave it the name that I have used, "umbrella cloud."

The sketch gives, perhaps, too much illumination of the figure. Centrally, at least, it was entirely black, or a very dark green, shading out to a lighter green near the edges. The columns of falling rain, their inclination inward, and the play of lightning were carefully drawn at the time. As to the play of lightning there was none from the umbrella cloud itself to either the mass above or the ground below. It was wholly between the upper cloud and the ground. Sometimes it passed beyond the central mass, sometimes this side, and occasionally entirely through it, as I have indicated.

The direction of travel was toward me and a little to the left, namely, toward a direction a little south of east. The right-hand edge of the suspended cloud passed over me. It appeared to lose its form as it approached, but this was to be expected on account of its size. I regret to say that I did not make note of directions of wind, excepting that the wind shifted rapidly in direction. There was no wind, however, from due south. As to its force, it was rather violent, breaking down a few slender trees, but I did not learn afterwards that at any point there had been anything like a tornado. What had appeared to be rain, however, turned out to be exceptionally heavy hail, sufficiently heavy to kill chickens and two or three young calves. The play of lightning was very rapid. After the cloud had passed, I could discern for a while a slight resemblance to its former appearance, but quite rapidly it lost that character entirely and disappeared on the horizon as an ordinary storm. The weather before and after was not only clear but exceptionally warm.

Mr. H. W. Menke, in his letter dated April 6, 1898, at Aurora, Wyo., says:

I am sorry I can not send a copy from the kodak negative, at least for a long time. I left home soon after making the photograph and have not been in Garden City (Kansas) since, except for a few days' visit.

But I doubt whether the photograph would be of any value to you. If I remember aright details are indistinct, and the print is so small it could hardly be used for reproduction. Your sketch illustrates the characteristic features of the cloud much more clearly than a photograph could have done.

You ask for comments. It is hardly in place for a novice like myself to offer suggestions on the work of a trained observer. Yet, I might mention a few points which appeared different to me.

I was not north of the cloud, as you supposed, but four miles due northwest of Garden City, hence observed the cloud from a very little north of east. I believe you saw it from Garden City.

Of course, our ideas with regard to distance may differ, as we may have made note at different times. At the time my photograph was made the cloud was not over eight miles distant. This is positive because I remember comparing its position with certain landmarks. Assuming this distance (from my point of view) as about correct, I am able to give a very fair estimate of the size of the cloud. This is ob-

tained from my remembrance of the photograph, the relations between the size of image on film, angle of lens, and distance from camera to object. The cloud varied in size, but when photographed it was not less than six miles wide, probably nearer seven than six.

From my point of view, the horns of the inverted funnel were not symmetrical. The cloud was centered in my photograph, but only one horn was included entire on the negative, the other being cut off and, therefore, longer.

Another difference I remember was in the upper part of Mr. Gill's drawing. The flat, shale-like forms which appear in his sketch were much more rounded, i. e., appeared to me like *huge rolls*, increasing in size, of cross sections from center outwards, the outermost several times larger than any of the others.

Also, I do not remember that the layer bounding the lower surface of the inverted funnel and from which rain was falling was so strongly contrasted from the funnel proper. Why not insert a lightning flash shooting from upper disk across lower portion? I saw them frequently.

On this letter Mr. Johnson submits the following remarks elucidating the minor differences between Mr. Menke and himself. He says:

Mr. Menke and I did not sketch the cloud simultaneously. He, however, made a photograph at the time. It was taken with a pocket kodak. It was a snap shot, and obscure. He gave me a copy. I compared it with my sketch but made no changes in the sketch; there was no need. I recently wrote to Mr. Menke asking for another. I will inclose his letter. [See above.] I am sorry I haven't the photograph, but I remember it quite distinctly, and I can say positively that it would merely enable you to make out the outline of the main figure unmistakably, but vaguely.

My estimate as to distance is, I am afraid, pretty rough guess work. I doubt also whether Menke's statement as to this is to be trusted, nor could I now make any estimate as to the height. It seems to me, as I think of it, quite likely that I have overestimated distances and dimensions.

Only one point I wish to emphasize. The structure was in no degree less symmetrical and altogether extraordinary than I have shown it. My sketch was very carefully made, with an effort to exaggerate nothing. [See the reprint of field sketch on Chart No. XI.] In the copy [see Chart No. XII] we have omitted the ranch buildings and trees. The country is a plain, and the cloud form was far beyond the ranch. If my point of view had been a few hundred yards nearer the foreground would have appeared as in the completed drawing. No line has been added to the original sketch, which was made at the time.

I sent Menke one of the photographic copies of Gill's drawing, but without the lightning, which I have since added in Chinese white. You will notice in his letter that he suggests the addition of lightning, from the upper mass to the ground, past the conical structure, as in the original drawing.

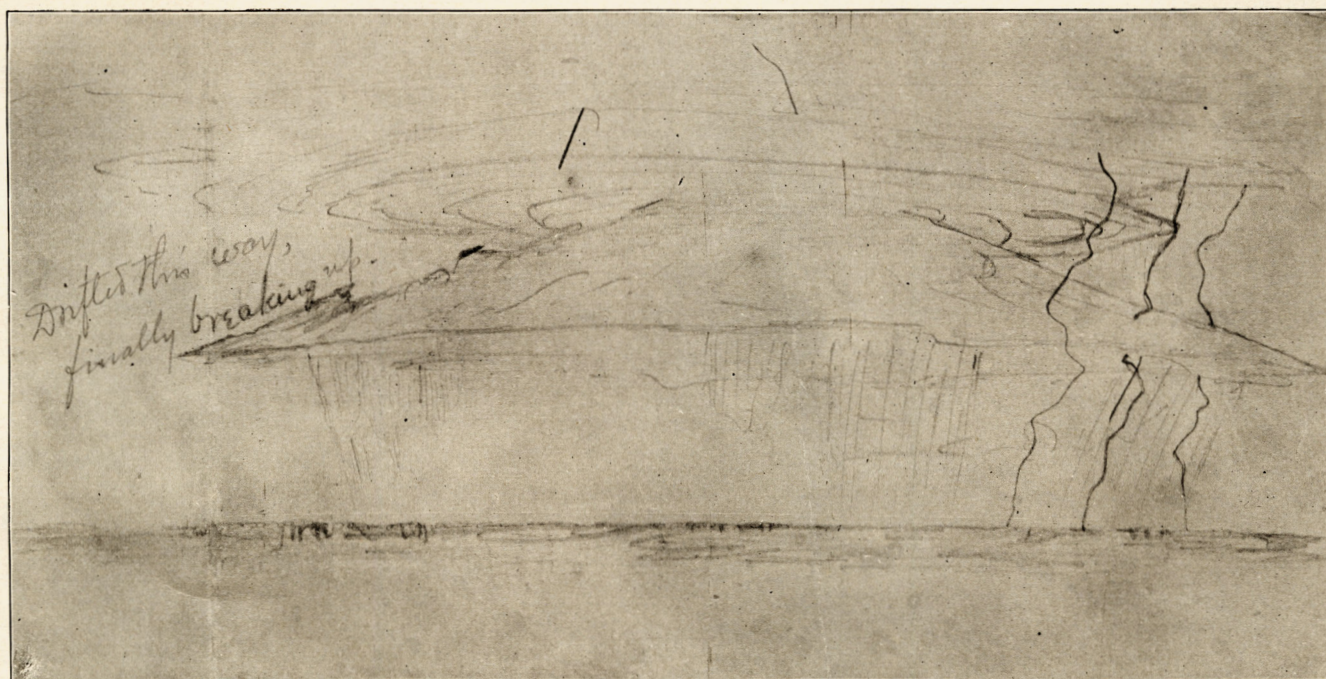
VOLUNTARY METEOROLOGICAL AND CROP REPORTING STATIONS.

By F. J. WALZ, Section Director, Weather Bureau, Baltimore, Md.

The general climatic history of the United States is recorded by that branch of governmental service known as the Weather Bureau, which consists of a central controlling station at Washington, D. C., and a number of well-separated regular meteorological stations, about 150 in all; the whole forming a system covering the entire country, each station of which is in swift telegraphic communication with the others and with the Central Office. The work of the Bureau has become familiar to all through its widely distributed publications, such as the daily forecasts and reports of weather and river conditions; the snow and ice charts; and cold wave, frost, and flood warnings; the weekly crop bulletins; the sectional and national monthly reports; and various timely publications of a special nature.

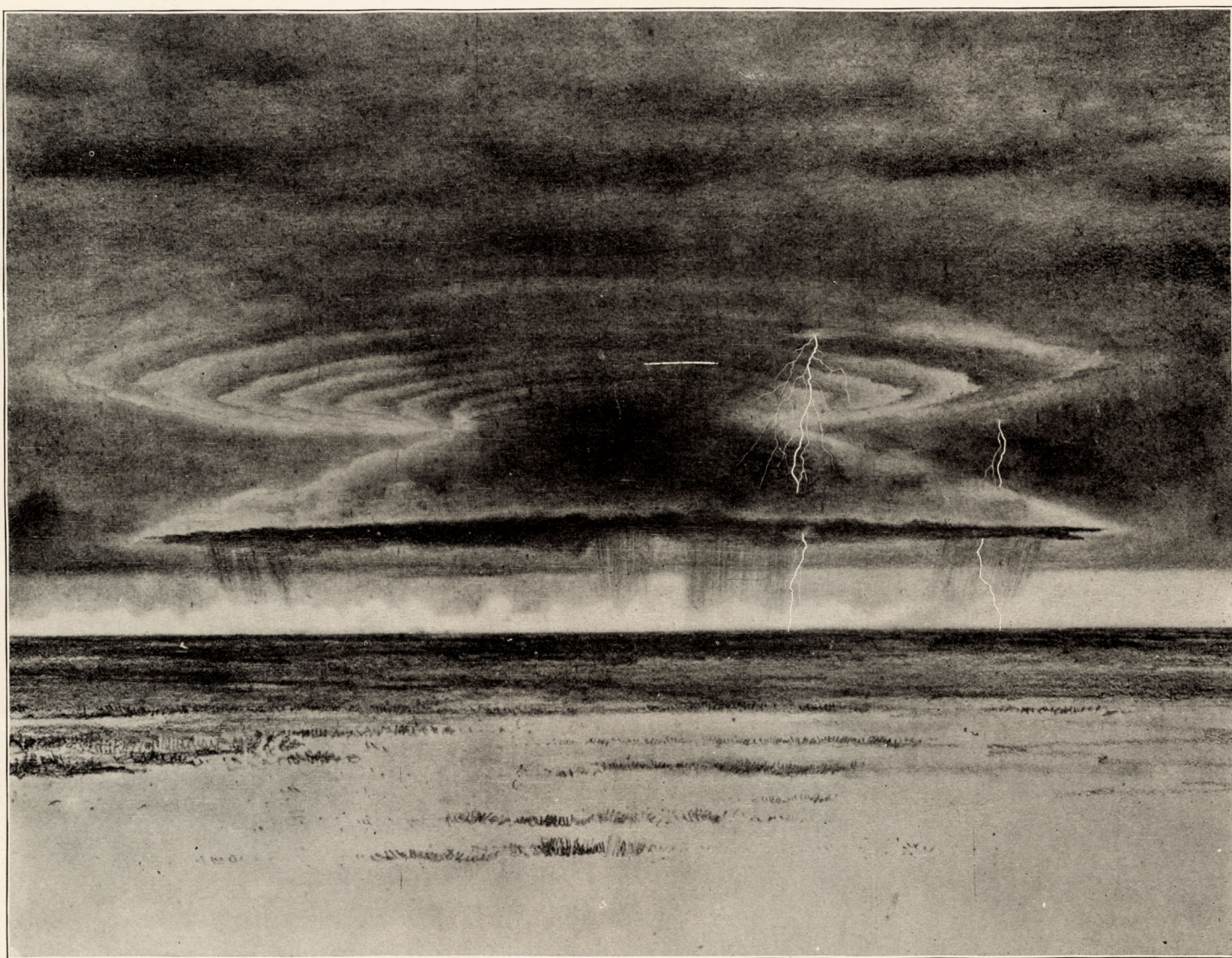
The detailed climatic history of the country, though subordinated to the main purposes of the Bureau, has been provided for in the following manner: One or more States are embraced under the control and supervision of a regular meteorological station, centrally located, to form a section. Points are then selected throughout each section for the location of voluntary stations making a record of temperature and rainfall, and of crop-reporting stations rendering weekly statements on the crops and farming operations during the growing season. At least one voluntary station is established

Chart XI. Sketches of Umbrella Cloud.



These sketches were made by Mr. W. D. Johnson on July 25, 1896, at Garden City, Kans., and are reproduced from his field note books without alteration.

Chart XII. Completed Drawing of Umbrella Cloud.



This drawing was made in 1897 by Mr. De Lancey W. Gill from the sketches and descriptions of Mr. Johnson.